Coronary perfusion: Impact of flow dynamics and geometric design of 2 different aortic prostheses of similar size

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Background: Aortic valve replacement leads to improvement of coronary flow but not to complete normalization. Coronary hypoperfusion contributes to higher left ventricular mass persistence, arrhythmias, congestive heart failure and sudden death. This prospective study compares 2 similarly sized aortic prostheses (mechanical and porcine) regarding coronary flow and hemodynamic performances in patients who underwent surgery for pure aortic stenosis.

Methods: Sixty patients having undergone aortic valve replacement for pure aortic stenosis with Medtronic Mosaic Ultra bioprosthesis 21 mm (n = 30) or St Jude Regent mechanical valve 19 mm (n = 30) were evaluated preoperatively and 12 months postoperatively comparing the coronary flow and the hemodynamic behavior. Echocardiography and cardiac positron emission tomography were performed at rest and during exercise or adenosine maximal stimulation, respectively.

Results: The St Jude Regent mechanical valve, compared with the Medtronic Mosaic Ultra bioprosthesis, had reduced coronary flow reserve (2.1 ± 0.3 vs 2.3 ± 0.2; $P = .003$), less favorable systolic/diastolic time ratio (0.87 ± 0.02 vs 0.78 ± 0.03; $P < .001$), and higher mean transprosthetic gradient (46 ± 11 vs 38 ± 9; $P = .003$) during exercise. Multivariate analysis of impaired coronary reserve related indexed effective orifice area less than 0.65 cm/m^2 (risk ratio [RR], 1.9; 95% confidence intervals [CI], 1.5-2.8; $P < .001$), mechanical valve (RR, 2.5; 95% CI, 1.7-3.3; $P < .001$), and systolic/diastolic time ratio greater than 0.75 (RR, 2.6; 95% CI, 1.8-3.8; $P < .001$), as well as high transprosthetic gradient (RR, 1.7; 95% CI, 1.3-2.4; $P < .001$)) during exercise with coronary reserve less than 2.2.

Conclusions: Improvement of coronary flow and reserve was more evident for bioprostheses than for mechanical valves. The bioprostheses demonstrated superior hemodynamics during exercise, which may have some impact on exercise capability during normal daily life. (J Thorac Cardiovasc Surg 2012;143:1030-5)

Myocardial blood flow (MBF) and coronary flow reserve (CFR) are reduced in patients with severe aortic stenosis. Aortic valve replacement (AVR) leads to improvement of coronary flow but not to complete normalization.[1-4] Chronic coronary hypoperfusion might contribute to cardiac events such as congestive heart failure and sudden cardiac death and might be related to persistence of high left ventricular mass.[1,5-8] Recent experimental studies hypothesized that, besides other variables, impaired coronary flow after AVR should be ascribed to a disturbed flow pattern in the proximal part of the aorta distal to the valve and suggested that valve size and design as well as residual transprosthetic gradient may influence coronary perfusion.[9,10] In addition, considering coronary perfusion also influenced by diastolic time, which is usually impaired after AVR, few data are available on the relationships between diastolic duration and coronary perfusion regarding the different behavior of mechanical and biological valve substitutes.

This study was designed to evaluate the impact of aortic valve design on MBF by means of several pathophysiologic and hemodynamic parameters measured at rest and during exercise. Two homogeneous groups of patients who received a similarly sized aortic prosthesis, divided according to mechanical or biological prostheses implanted, were compared. Cardiac cycle abnormalities and hemodynamic parameters were measured by Doppler echocardiography at rest and during exercise. MBF and CFR were evaluated by cardiac positron emission tomography (PET) at rest and during pharmacologically induced hyperemia.

MATERIAL AND METHODS

Description of the Implanted Prostheses

To obtain 2 homogeneous groups and avoid any misleading interference owing to comparison of prostheses different in size, design, and structure, we aimed to perform an ''actual size'' analysis between 2 valve substitutes and held more realistic to evaluate patients with an aortic annulus of 20 mm (the most common size of aortic annulus in prosthetic

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Disclosures: Authors have nothing to disclose with regard to commercial support.
Received for publication March 1, 2011; revisions received May 12, 2011; accepted for publication June 7, 2011; available ahead of print July 13, 2011.

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0022-5223/$36.00

doi:10.1016/j.jtcvs.2011.06.011

Abbreviations and Acronyms

AVR = aortic valve replacement
CFR = coronary flow reserve
CI = confidence intervals
LVDT = left ventricular diastolic time
LVET = left ventricular ejection time
MBF = myocardial blood flow
MMU = Medtronic Mosaic Ultra
PET = positron emission tomography
RR = risk ratio
SJR = St Jude Medical Regent

implants for pure aortic stenosis). For the purpose of this study, we selected the St Jude Medical Regent (SJR) (St Jude Medical Inc, St Paul, Minn) 19-mm valve as the mechanical valve and the Medtronic Mosaic Ultra (MMU) (Medtronic Inc, Minneapolis, Minn) 21-mm valve as the bioprosthesis.

Differently sized mechanical (SJR 19 mm) and biologic (MMU 21 mm) prostheses were chosen because of the sizer provided by the manufacturers; the 21-mm MMU is clearly smaller (19.5 mm) than the 21-mm SJR (21 mm) when measured with slide callipers.[11] Conversely, the actual external sewing ring diameter, which is the maximum diameter of a prosthesis, was similar in SJR 19-mm and MMU 21-mm valves (19 mm vs 19.5 mm, respectively), as well as the internal orifice diameter, which is the factor that mainly affects the effective orifice area (17.8 mm vs 17.5, respectively).

Patient Population

Between January 2007 and August 2009, a total of 189 patients undergoing AVR for pure aortic stenosis with an aortic annulus of 19 to 21 mm, determined after adequate (transthoracic and/or transesophageal) echocardiographic examination, were evaluated for inclusion in the study. All patients had aortic maximum gradient greater than 50 mm Hg and/or aortic valve area less than 1.0 cm^2 and angiographically normal coronary arteries before surgery. Mean age was 62.2 ± 7.2 years (range, 55-69 years). To obtain a study population as homogeneous as possible and to avoid any confounding interference on results, we used the following exclusion criteria: age less than 55 years or over 70 years, active endocarditis, emergency surgery, previous cardiac surgery, bicuspid aortic valve, associated aortic diseases, simultaneous mitral or tricuspid replacement or repair, poor cardiac function as indicated by ejection fraction less than 40%, chronic atrial fibrillation, severe comorbidities (dialysis, hepatic failure, autoimmune disease), impediments to exercise test (neurologic or osteoarticular), and contraindications to receive adenosine (heart block or reactive respiratory disease). Thirty patients received a 21-mm MMU bioprosthesis (MMU group) and 30 a 19-mm SJR mechanical bileaflet valve (SJR group). The choice was based on history of thromboembolism or bleeding disorders, liver disease, and preference of the patient or cardiologist.

All patients from both groups underwent echocardiographic (transthoracic or transesophageal) evaluations and PET scans at rest within a 2-week preoperative period. Postoperative echocardiographic assessment at rest and during exercise as well as PET scans at rest and during maximal adenosine stimulation were performed 12 months after surgery. Follow-up was started at 12 months because prosthetic gradients usually change during the first postoperative year with significant impact either on the exercise capability or on the hemodynamic results.[11]

The Institutional Research Ethics Committee of the University of Naples approved this study and all patients provided written informed consent.

Surgical Technique

The surgical approach consisted in median sternotomy, hollow-fiber oxygenators, and a centrifugal blood pump. The ascending aorta and right atrium were cannulated. Pump flow was kept at about 2.5 $L \cdot min^{-1} \cdot m^{-2}$ and the arterial pressure at about 70 mm Hg. The myocardium was protected by intermittent cold crystalloid cardioplegia. Aortic annulus diameter was measured by Hegar dilators. Thereafter, prosthetic valve size was determined by using the original sizer by each manufacturer. All prostheses were implanted with 2-0 polyester nonpledget-supported, interrupted, noneverting mattress sutures. Mean aortic crossclamping time was 65.4 ± 20.3 minutes. The MMU valves were implanted according to the manufacturer recommendations regarding the asymmetric design. The SJR valves were implanted respecting the optimum hemodynamic orientation achieved with one orifice facing the right coronary cusps.[8] Patients with the SJM valve received postoperative lifelong warfarin anticoagulation. Patients with the MMU bioprosthesis received warfarin for 8 to 12 weeks only.

Echocardiographic Measurements and Calculations

The echocardiographic examinations were performed according to the recommendations of the American Society of Echography.[12] Left ventricular function was evaluated by the ejection fraction calculated by the Simpson rule. The left ventricular mass was normalized to body surface area. Left ventricular hypertrophy was defined as indexed left ventricular mass more than 130 g/m^2 in men and more than 100 g/m^2 in women.[13] The peak and mean prosthetic gradients were calculated from continuous-wave Doppler measurements using the modified Bernoulli equation. Stroke volume was indexed for body surface area. The continuity equation was used to calculate the effective orifice area.

Valve regurgitation was assessed by color flow Doppler mapping and continuous-wave Doppler (transthoracic or transesophageal) as the total backflow volume occurring after the aortic prostheses was fully closed. The evaluation of the SJR was possible only by the optimal orientation of the viewing plane as a consequence of the more complex arrangement of regurgitant jets.

Left ventricular ejection time (LVET) was measured on the continuous-wave Doppler trace from opening to closing of the aortic valve. Left ventricular diastolic time (LVDT) was determined as R-R interval–LVET. LVET/LVDT ratio was assessed as well. All measurements are given as the average of 3 consecutive cardiac cycles at rest or 10 cycles during exercise.

Exercise Protocol

Stress test was performed in all patients 5 days after therapy withdrawal. The exercise test was performed with the patients exercising in the supine position and was conducted according to a standard protocol starting from a workload of 25 W and increased by 25 W at 2-minute intervals. The reference workload for healthy individuals was 2.5 W/kg in women and 3.0 W/kg in men between 21 and 30 years, minus 10% for each decade. Tests were limited by symptoms, blood pressure greater than 180/100 mm Hg, arrhythmias, and exhaustion or achievement of 100% of age and/or sex reference workload. The evaluation of LVET and LVDT was obtained at a heart rate of 100 beats/min while peak prosthetic gradient, mean prosthetic gradient, and effective orifice area were assessed at peak exercise.

Quantification of MBF

Cardiac PET was performed on a Siemens ECAT EXACT 3-dimensional positron scanner (Siemens AG, Munich, Germany). PET perfusion tracer was $^{13}NH_3$ given intravenously as a bolus. Rest and stress arterial radiopharmaceutical administration consisted of 370 to 740 MBq (10-20 mCi) of $^{13}NH_3$. All substances that interfere with adenosine methabolism, such as caffeine and other methylxanthine derivatives, were withheld 12 hours before the study. Regions of interest were septal, anterior, lateral, and posterior walls of the left ventricle in the apical, mid, and basal

planes. Tissue time activity curves were generated from the dynamic image and fitted to a single tissue compartment tracer kinetic model to give values of MBF (mL · min^{-1} · g^{-1}). Coronary flow was measured at baseline and after maximal hyperemic response obtained within 90 seconds of venous adenosine infusion (140 $\mu g \cdot kg^{-1} \cdot min^{-1}$). The CFR was the ratio between hyperemic and baseline MBF.

Statistical Analysis

Data were analyzed by SPSS version 15 for Windows (SPSS, Inc, Chicago, Ill). Comparison between continuous variables was done by the Student *t* test for normally distributed features. The Mann-Whitney *U* test was used for variables not normally distributed. Categorical variables were analyzed by χ^2 test or Fisher's exact test as appropriate. Continuous data are presented as mean ± standard deviation and categorical data as proportion. Factors influencing coronary flow were analyzed by calculating the risk ratio (RR) with 95% confidence intervals (CI). Multivariate logistic analysis was performed with a stepwise regression model, in which each variable with a *P* value ≤ .05 (on the basis of univariate analysis) was entered into the model. The variables tested in the models were as follows: sex, body surface area, preoperative indexed left ventricular mass, indexed effective orifice area, type of prosthesis implanted, CFR during hyperemic stimulation, mean prosthetic gradient greater than 50 mm Hg, LVDT, and LVET/LVDT ratio during exercise.

RESULTS

Patient Characteristics

Demographics were similar for MMU and SJR valve recipients. The incidence of severe prosthesis-patient mismatch was similar in both groups. Mean indexed orifice area was 0.73 ± 0.07 in patients from the MMU group versus 0.75 ± 0.08 in patients from the SJR group ($P = .3$). Myocardial ischemia and cardiopulmonary bypass times were similar for all patients. No differences were found either in intensive therapy unit stay or hospital stay (Table 1).

Fifty-two percent of patients received β-blockers, 12% angiotensin-converting enzyme inhibitors, and 36% had β-blockers and angiotensin-converting enzyme inhibitor therapy.

Postoperative Echocardiographic Evaluation at Rest

One year after surgery, baseline heart rate, systolic blood pressure, cardiac index, and indexed stroke volume were similar in both groups. Peak and mean transvalvular pressure gradients at rest were low in both SJR and MMU groups (peak 25 ± 9 mm Hg vs 27 ± 11 mm Hg; $P = .4$; mean 11 ± 7 mm Hg vs 13 ± 9 mm; $P = .3$; respectively). Overall, no significant regression of indexed left ventricular mass was observed in both groups at either 6 months ($P = .8$) or 1 year after surgery ($P = .7$), although the response was heterogeneous at the individual level.

The LVET and LVDT at rest occupied 38% ± 3% and 62% ± 5%, respectively, of the cardiac cycle without any significant difference between groups. Doppler-derived hemodynamic and myocardial blood flow data at rest are reported in Table 2.

TABLE 1. Preoperative and surgical variables

	Mosaic Ultra (n = 30)	St Jude Medical Regent (n = 30)	*P* value
Male sex	19 (63.3%)	21 (70%)	.7
Age (y)	64 ± 5	63 ± 3	.3
BSA m^2	1.91 ± 0.21	2.01 ± 0.27	.1
BMI	27.5 ± 2.2	27.8 ± 2.6	.6
Moderate PPM	21 (70%)	22 (73.3%)	1
Severe PPM	9 (30%)	8 (26.7%)	1
EOAi (cm^2/m^2)	0.73 ± 0.07	0.75 ± 0.08	.3
LVEF (%)	58 ± 9	56 ± 7	.7
ILVM (g/m^2)	171 ± 51	165 ± 49	.6
CI ($L/min/m^2$)	2.28 ± 0.3	2.32 ± 0.5	.7
ISV ($mL/beat/m^2$)	28 ± 6	30 ± 7	.2
Crossclamp time (min)	58 ± 16	62 ± 15	.3
Pump time (min)	78 ± 17	79 ± 21	.8
ICU stay (hours)	32 ± 11	33 ± 9	.7
Hospital stay (days)	7.3 ± 3.2	7.8 ± 6.1	.6

Values are expressed as mean ± standard deviation or number (%). The *P* value was determined by analysis of variance or χ^2 test (gender, moderate PPM, severe PPM). *BSA,* Body surface area; *BMI,* body mass index; *PPM*, prosthesis-patient mismatch; *EOAi,* indexed effective orifice area; *LVEF,* left ventricular ejection fraction; *ILVM,* indexed left ventricular mass; *CI,* cardiac index; *ISV,* indexed stroke volume; *ICU,* intensive care unit; *moderate PPM,* EOAi < 0.85 and > 0.65; *severe PPM,* EOAi < 0.65.

The SJR valve showed a complex arrangement of regurgitant jets that were dependent on the orientation of the viewing plane. In the plane perpendicular to closure line, 2 divergent jets arising in the valve periphery (inverted V shape) and an additional small regurgitation jet from the center of the valve were seen. The backflow was significant (10%-15% of forward flow) in the SJR valve whereas it was negligible with an MMU valve.

Mechanical valves also showed a high level of systolic turbulence in the aortic root, although optimally oriented.

Hemodynamic Performance During Exercise

In the MMU group the peak transvalvular gradients increased to 49 ± 1 mm Hg whereas the mean transvalvular gradients increased to 38 ± 9 mm Hg from baseline. In the SJR group they increased to 53 ± 12 and to 45 ± 11 mm Hg, respectively, with statistically significant differences between groups ($P < .01$) (Figure 1). Effective orifice area did not change with flow in patients from the SJR group at peak exercise, but it was slightly increased in patients from the MMU group. These results may not be surprising because bioprostheses are flexible and open more gradually in response to an increase in flow.

Cardiac cycle duration, which is algebraically dependent on heart rate, fell from a mean of 750 ms at rest to 600 ms during exercise at a heart rate of 100 beats/min. The LVET decreased during stress from 300 ± 24 ms to 260 ± 12 ms in the MMU group and from 290 ± 21 ms to 280 ± 15 ms in the SJR group. The LVDT decreased from 450 ± 25 ms to 340 ± 16 ms in the MMU group

TABLE 2. Postoperative Doppler-derived hemodynamic and myocardial blood flow data at rest, during exercise, and after maximal adenosine stimulation

	Baseline			Maximal stimulation		
	MMU 21 mm (n = 30)	SJR 19 mm (n = 30)	*P* value	MMU 21 mm (n = 30)	SJR 19 mm (n = 30)	*P* value
HR (beats/min)	81 ± 13	78 ± 16	.4	100	100	
AP (mm Hg)	135 ± 21	130 ± 19	.3	172 ± 31	164 ± 28	.2
CI (L/min)	2.36 ± 0.4	2.30 ± 0.5	.6	4.58 ± 0.43	4.60 ± 0.38	.8
ISV (mL/beat)	30 ± 4	29 ± 5	.4	46 ± 6	46 ± 3	1
MPG (mm Hg)	13 ± 9	11 ± 7	.3	38 ± 9	45 ± 11	.008
PPG (mm Hg)	27 ± 11	25 ± 9	.4	47 ± 10	53 ± 12	.01
AVF (mL/s)	200 ± 35	202 ± 42	.8	338 ± 35	326 ± 41	.2
LVET (ms)	300 ± 24	290 ± 21	.09	260 ± 12	280 ± 15	<.001
LVDT (ms)	450 ± 25	460 ± 19	.07	340 ± 16	320 ± 11	<.001
LVET/LVDT	0.66 ± 0.04	0.64 ± 0.06	.1	0.76 ± 0.03	0.85 ± 0.02	<.001
MBF (mL/min/g)	1.02 ± 0.2	0.96 ± 0.28	.3	2.34 ± 0.32	2.01 ± 0.41	.001
CFR				2.3 ± 0.2	2.1 ± 0.3	.003

Values are expressed as mean ± standard deviation and p value determined by analysis of variance. *MMU,* Medtronic Mosaic Ultra; *SJR,* St Jude Medical Regent; *HR,* heart rate; *AP,* arterial pressure; *CI,* cardiac index; *ISV,* indexed stroke volume; *MPG,* mean prosthetic gradient; *PPG,* peak prosthetic gradient; *AVF,* aortic volume flow; *LVET,* left ventricular ejection time; *LVDT,* left ventricular diastolic time; *MBF,* myocardial blood flow; *CFR,* coronary flow reserve.

and from 460 ± 19 ms to 320 ± 11 ms in the SJR group. When LVET and LEDT are considered as proportions of the cardiac cycle, systolic time during exercise increased from 39% ± 3% at rest to 44% ± 4% in the MMU group and from 38% ± 4% to 47% ± 5% in the SJR group whereas diastolic time decreased from 60% ± 5% to 56% ± 5% and from 61% ± 4% to 53% ± 4%, respectively. During exercise, at heart rates of 100 beats/min, LVET/LVDT ratio was lower in the MMU group than in the SJR group (0.76 ± 0.03 vs 0.85 ± 0.02; $P < .001$). Therefore, as a general rule, despite shortening of cardiac cycle duration during exercise, systole duration was not linearly related to heart rate. However, the relation between the duration of systole and diastole and the systolic/diastolic time ratio were different in the 2 groups of patients (Table 2).

MBF

Resting MBF increased from preoperative 0.87 ± 0.39 to 0.96 ± 0.28 mL · min^{-1} · g^{-1} (+9%) at follow-up in the SJR group and from 0.85 ± 0.38 to 1.02 ± 0.27 mL · min^{-1} · g^{-1} (+16%) in the MMU group. Hyperemic MBF increased from preoperative 1.46 ± 0.52 to 2.01 ± 0.85 mL · min^{-1} · g^{-1} (+26 %) at follow-up in the SJR group and from 1.47 ± 0.61 to 2.34 ± 0.73 mL · min^{-1} · g^{-1} (+36%) in the MMU group (Figure 2). CFR increased from preoperative 1.68 to 2.1 (+20%) at follow-up in the SJR group and from 1.72 to 2.3 (+26%) in the MMU group (Table 2).

Relationships Between Measured Parameters

Multivariate predictors of coronary reserve less than 2.2 during adenosine hyperemic stimulation were indexed effective orifice area less than 0.65 cm/m^2 (RR, 1.9; 95% CI, 1.5-2.8; $P < .001$), mechanical valve (RR, 2.5; 95%

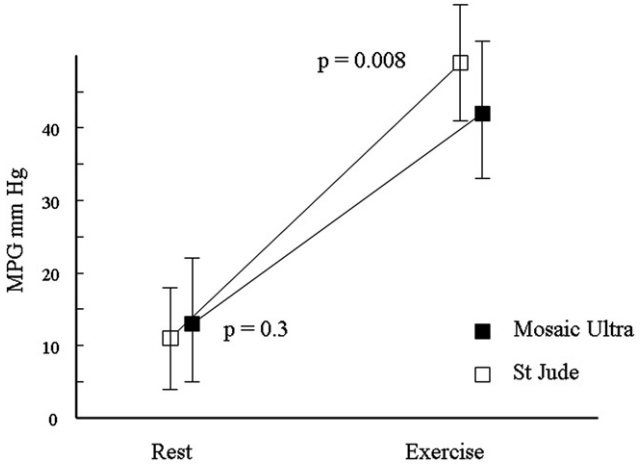

FIGURE 1. Mean prosthetic gradients *(MPG)* of Medtronic Mosaic Ultra bioprostheses and St Jude Medical mechanical valve at rest and during exercise.

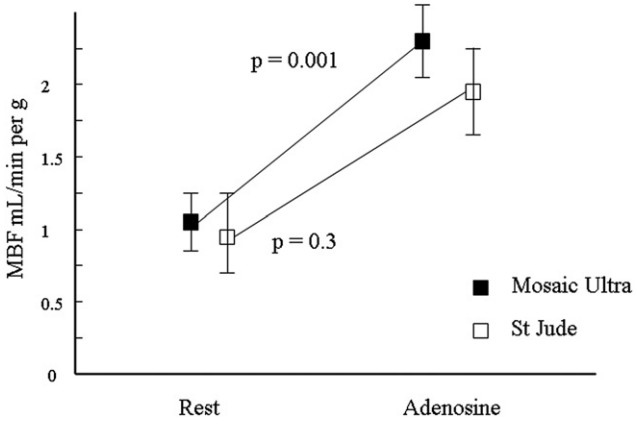

FIGURE 2. Myocardial blood flow *(MBF)* of Medtronic Mosaic Ultra bioprosthesis and St Jude Medical mechanical valve at rest and during adenosine.

CI, 1.7-3.3; $P < .001$), LVET/LVDT ratio greater than 0.75 (RR, 2.6; 95% CI, 1.8-3.8; $P < .001$), and mean prosthetic gradient less than 50 mm Hg (RR, 1.7; 95% CI, 1.3-2.4; $P < .001$) during exercise.

DISCUSSION

The mechanisms responsible for the only partially recovered coronary flow after AVR have been largely debated. Rajappan and associates[1] demonstrated that the improvement of coronary perfusion is mainly dependent on the improvement of valve effective orifice area achieved with AVR. Nonetheless, although mechanical and biological valves are usually stenotic to some extent, it was surprising that only a negligible residual transprosthetic gradient can impair coronary perfusion.

Besides the variables related to microvascular remodeling and altered distribution of coronary vascular resistance in patients with high left ventricular mass, Kleine,[9] Bakhtiary,[14,15] and their associates hypothesized that blunted coronary perfusion should also be ascribed to a disturbed flow pattern in the proximal part of the aorta distal to the valve, and they drew the attention to diastolic performance of valve substitutes. In this regard, they suggested that different types and orientations of aortic valve prostheses could affect myocardial perfusion in a different way.[9,10] However, the complex pathophysiologic relationship between coronary flow and different hemodynamic of mechanical and biological prostheses had not been clearly elucidated before.

Our results confirmed that AVR led to improvement of MBF but not to a complete restoration in nearly all patients. Overall, impaired MBF and reserve during hyperemic stimulation were strongly linked with high indexed left ventricular mass, increased mean prosthetic gradient, and impaired LVET/LVDT ratio during exercise. However, patients with mechanical valves had more blunted hyperemic MBF and CFR and developed significantly higher mean prosthetic gradients during exercise as compared with patients with bioprostheses. These results confirm that transprosthetic gradient, exacerbated during exercise, could have a detrimental effect on MBF determined also by the rounded backflow enhancing aortic valve closure and by the flow pattern through the aortic valve and the sinuses of Valsalva. In this regard, although optimally orientated, the SJR valve developed a high level of turbulence and had a relatively large total regurgitant volume across the closed valve.[16] High systolic downstream turbulence, closing reflux, and leakage flow combined to create disturbed flow in the sinuses of Valsalva and allowed a less physiologic diastolic coronary perfusion. Conversely, the MMU bioprosthesis demonstrated a central flow very close to the natural geometry, hallowing a less turbulent flow passage during the systolic phase of cardiac cycle and a physiologic leaflet closure during the diastolic phase with negligible regurgitation.[17]

This study also revealed evident stress-induced abnormalities of the cardiac cycle in all patients after AVR. As is widely known, the total cardiac cycle duration is algebraically dependent on the heart rate (60,000 ms/heart rate), which is the major determinant affecting diastolic and systolic duration. Systolic time has a negative linear correlation with heart rate. Diastolic time has a more complex relation: it is longer at low heart rates and decreases more markedly than systolic time during exercise. Coronary perfusion is a function of both diastolic duration and systolic/diastolic ratio. The physiologic relationship between diastolic time-shortening during exercise and coronary perfusion has been well documented over time.[18] However, there are no prior studies relating to the influence on coronary perfusion of differing hemodynamic behaviors of mechanical and biological prostheses after AVR. Our results, despite similar values at rest in both groups, focused a significantly shortened LVDT and LVET/LVDT ratio during exercise in patients from the SJR group, which were strongly related to impaired hyperemic MBF.

Hence, the worse performance of the SJR valve during exercise depends on a number of cofactors, but, in addition, it could also be attributed to the rigid structure of mechanical valves that destroys completely the delicate physiological mechanism of active annulus motion and aortic root expansion at each phase of the cardiac cycle.[19] Conversely, our study seems to substantiate the key role of highly flexible stent of the MMU valve which, during physical activity, allows better deformational dynamics and torsion of the aortic root as compared with rigid structure of mechanical valve.

Study Limitations

The number of patients in the study groups was small. Thus, the power to comment might be somewhat limited. However, the main strength of the study relies on the number of variables analyzed that validate the model for additional series of patients.

CONCLUSIONS

Our study supports the evidence of a significant linkage among reduced coronary flow, impaired hemodynamic profiles, and higher mean prosthetic gradient values in patients who underwent AVR with persistently high indexed left ventricular mass. The evaluated valve substitutes provided both satisfactory hemodynamic results at rest. However, MMU bioprostheses showed a better behavior with lower gradients during exercise as compared with SJR valves of the same ''actual size.'' The intrinsic characteristics of the mechanical valve deeply interfered with flow dynamics during exercise. Our results and others from similar studies could support a reassessment of actual guidelines on the valve choice for AVR regardless of patient age.

We thank Dr GiovanBattista Mannacio from Bocconi University of Milan for assistance with statistical analysis.

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